(12) UK Patent Application (19) GB (11) 2 186 144 (13) A

(43) Application published 5 Aug 1987

(21) Application No 8700322

(22) Date of filing 8 Jan 1987

(30) Priority data
(31) 8602309 (32) 30 Jan 1986 (33) GB

(71) Applicant
PA Consulting Services Limited

(Incorporated in United Kingdom)

Hyde Park House, 60a Knightsbridge, London SW1

(72) Inventors
Craig George Sawyers
Allen William Mabbitt

(74) Agent and/or Address for Service
Keith W. Nash & Co.,
Pearl Assurance House, 90–92 Regent Street,
Cambridge CB2 1DP

(51) INT CL⁴
H04B 9/00

(52) Domestic classification (Edition I):
H4B B

(56) Documents cited
None

(58) Field of search
H4B
Selected US specifications from IPC sub-class H04B

(54) Optical demultiplexer

(57) A detector for demultiplexing light signals containing components of differing wavelengths (L1, L2), comprises a plurality of Schottky barrier detectors (26, 28) having parallel-grooved surfaces successively receiving the light at angles of incidence (A1, A2) such that components L1 are absorbed by plasmon resonance at Shottky barrier detector 26 and components L2 are similarly absorbed at Schottky barrier detector 28.

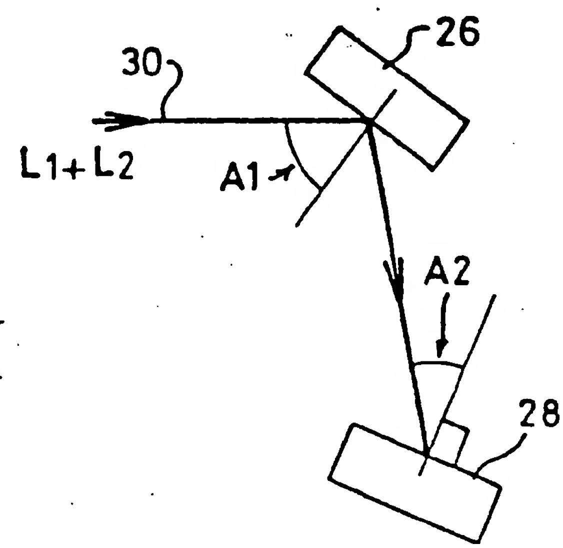

Fig.3

BEST AVAILABLE COPY

GB 2 186 144 A

-8 JAN.87- 00322

2186144

1/1

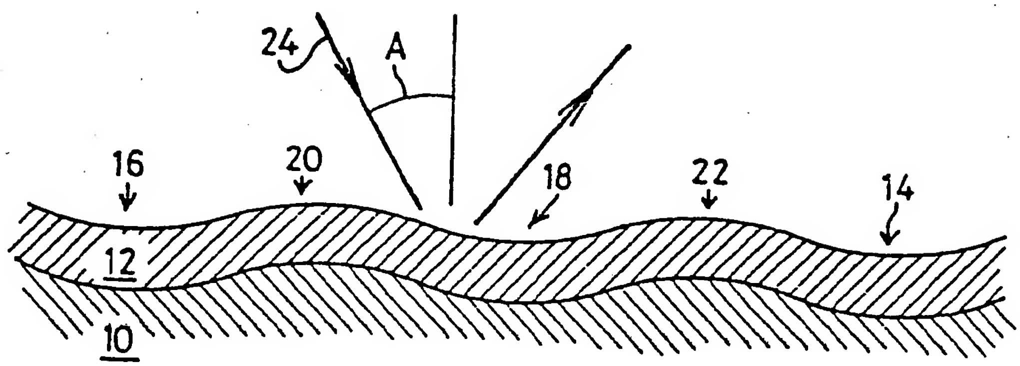

Fig.1

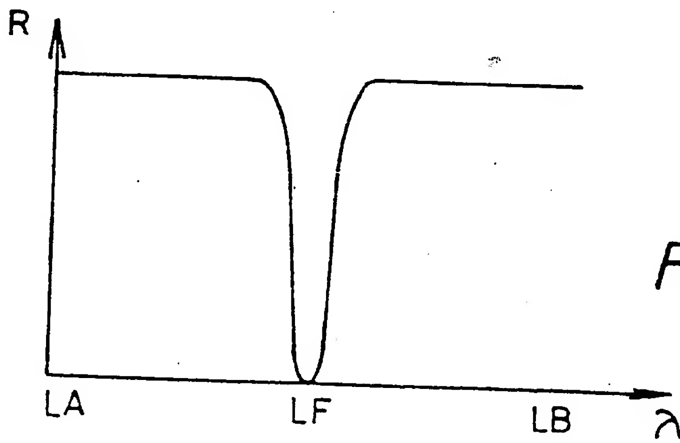

Fig.2

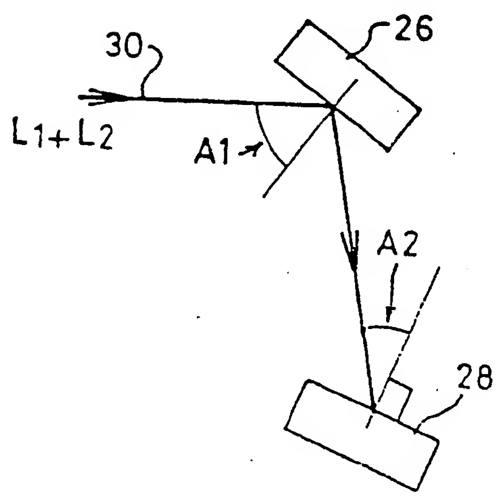

Fig.3

BEST AVAILABLE COPY

SPECIFICATION

Optical demultiplexer

Field of invention

This invention concerns optical demultiplexers by which light of one wavelength can be separated from light of another wavelength.

Background to the invention

In optical fibre communication systems, higher data transmission rates can be achieved by transmitting light signals at two differing wavelengths along the same optical path. Two preferred wavelengths for fibre optic transmission paths are 1.3 um and 1.55 um.

It is an object of the invention to provide a device by which light of one wavelength can be separated from light of the other wavelength.

It is another object of the invention to provide a device which can be adapted to separate any number of light signals provided they are all of differing wavelengths.

Summary of the invention

According to the present invention a detector which is capable of demultiplexing *n* light signals each having a different wavelength L1, L2 .... Ln comprises a first Schottky barrier detector the light receptive surface of which is profiled with a plurality of parallel grooves or ridges so that surface plasmon resonance will occur if light is incident then and (n−1) further Schottky barrier detectors each having a light receptive surface which is profiled in a similar manner to the first; projection means for projecting light containing all *n* signals onto the light receptive surface of a first of the detectors at an angle of incidence AI, such that surface plasmon resonance, and therefore absorption, will occur in respect of any component having a wavelength L1, all other components being reflected by the surface, and wherein a second one of the detectors is arranged to receive any light reflected by the first detector surface at an angle of incidence A2 such that surface plasmon resonance (and therfore absorption) will ocur at the second detector in respect of any component having a wavelength L2, all other components being reflected by the surface, and each of the (n−2) remaining detectors is arranged to receive light in its turn from a preceeding detector in a manner similar to that in which the said second detector, receives light from the first detector at angles of incidence A3, A4 .... An, such that resonance (and therefore absorption) will occur at each said detector in respect of a different one of the components L3, L4 .... Ln, and any remaining components will be reflected.

The condition for establishing surface plasmon resonance is related to the groove pitch A_g, the light wavelength A_l and the angle of incidence θ by the equation (to first order):-

$$\frac{1}{A_l}\sin\theta \pm \frac{n}{A_g} = \frac{1}{A_l}\,\frac{Em}{Em+1}^{\frac{1}{2}}$$

where Em is the (complex) dielectric constant of the metal. For typical metals, Em is nearly real, negative, and has modules much larger than unity (eg. silver, Em$\simeq$-40 in the visible range). Thus the quantity $(Em/Em+1)^{\frac{1}{2}}$ is very close to unity. Generally, therefore:-

$$\frac{1}{A_l}\sin\theta \pm \frac{n}{A_g} \simeq \frac{1}{A_l}$$

which corresponds to the equation identifying diffraction of light by a grating, when the nth diffracted order emerges at an angle of 90° to the normal (ie. skims the surface of the metal).

In the simple case in which it is derived to separate two components L1 and L2 both present in an input signal, two detectors are provided, one receptive of the light signal at an angle of incidence A1 such that any L1 component sets up surface plasmon resonance in the first detector surface and is therefore absorbed and detected, whilst all other wavelengths (including L2) are reflected, and a second detector positioned relative to the first so as to receive any light reflected from the first detector at an angle of incidence A2, such that any component of wavelength L2 is absorbed (and therefore detected) by the second detector.

The invention will be described by way of example with reference to the accompanying drawings in which:

Figure 1 is an enlarged cross section through a Schottky barrier detector having a profiled surface as required by the invention,

Figure 2 illustrates graphically the variation of reflected energy with wavelength, for a given angle of incidence, and

Figure 3 illustrates diagramatically how two detectors can be arranged to provide for demultiplexing two signals L1 and L2.

In Fig. 1 a Schottky barrier detector is shown in part as being formed from n-type silicon (layer 10), and a thin metal layer 12, forming a receiving and reflecting surface 14. The silicon is profiled so as to define a plurality of parallel grooves 16, 18 etc. separated by ridges 20, 22 etc..

A light beam 24 is shown incident on the surface 24 at an angle A. If the wavelength of the light in the beam 24 is varied in the range of wavelengths LA to LB then for a given spacing and depth of the grooves 16, 18 etc, a response curve of reflected energy against wavelength will be obtained as is shown in Fig. 2. Here reflected power R is plotted against wavelength and it will be seen that at one particular wavelength. LF, the reflected energy is substantially zero. It is at this wavelength that surface plasmon resonance occurs, resulting in virtually 100% absorption of the light of that wavelength.

A similar response curve is obtained if, instead of varying wavelength, light of constant wavelength is projected onto a profiled surface at differing angles of incidence.

In the present invention, this fact is utilised to advantage in that the angle of incidence A1 is selected so that resonance (and therefore absorption) occurs at wavelength L1 at detector 26 leaving predominantly L2 components to pass to detector 28. This is angled relative to 26 so that the angle of incidence A2 is such that resonance and absorption occur at wavelength L2 at the second detector.

The electrical output from detector 36 will thus be proportional to the L1 wavelength component and that from 28 will be proportional to the L2 wavelength component, in the input light beam 30.

CLAIMS

1. According to the present invention a detector which is capable of demultiplexing *n* light signals each having a different wavelength L1, L2 .... Ln comprises a first Schottky barrier detector the light receptive surface of which is profiled with a plurality of parallel grooves or ridges so that surface plasmon resonance will occur if light is incident therein and (n−1) further Schottky barrier detectors each having a light receptive surface which is also profiled with parallel grooves or ridges; projection means for projecting light containing all *n* signals onto the light receptive surface of a first of the detectors at such an angle of incidence that surface plasmon resonance, and therefore absorption, will occur in respect of any component having a wavelength L1, all other components being reflected by the surface, and wherein a second one of the detectors is arranged to receive any light reflected by the first detector surface at such an angle of incidence that surface plasmon resonance (and therefore absorption) will occur at the second detector in respect of any component haveing a wavelength L2, all other components being reflected by the surface, and each of the (n−2) remaining detectors is arranged to receive light in its turn from a preceding detector, in a manner similar to that in which the said second detector receives light from the first detector, each at such an angle or incidence that resonance (and therefore absorption) will occur at each said detector in respect of a different one of the components L3, L4 .... Ln, and any remaining components will be reflected.

2. A detector capable of demultiplexing *n* light signals each having a different wavelength L1, L2 .... Ln, comprising a first Schottky barrier detector the light receptive surface of which is profiled with a plurality of parallel grooves or ridges so that surface plasmon resonance will occur if light is incident therein and (n−1) further Schottky barrier detectors each having a light receptive surface which is profiled in a similar manner to the first; projection means for projecting light containing all *n* signals onto the light receptive surface of a first of the detectors at an angle of incidence A1, such that surface plasmon resonance, and therefore absorption, will occur in respect of any component having a wavelength L1, all other components being reflected by the surface, and wherein a second one of the detectors is arranged to receive any light reflected by the first detector surface at an angle of incidence A2 such that surface plasmon resonance (and therefore absorption) will occur at the second detector in respect of any component having a wavelength L2, all other components being reflected by the surface, and each of the (n−2) remaining detectors is arranged to receive light in its turn from a preceding detector, in a manner similar to that in which the said second detector receives light from the first detector, at angles of incidence A3, A4 .... An,. such that resonance (and therefore absorption) will occur at each said detector in respect of a different one of the components L3, L4 .... Ln, and any remaining components will be reflected.

3. A detector according to claim 1 or 2, comprising two Schottky barrier detectors for separating light signals of two differing wavelengths.

4. A detector according to any one of claim 1 to 3, wherein each Schottky barrier detector comprises an n-type silicon substrate having a profiled surface and a thin metal layer of uniform thickness deposited on the profiled surface of the substrate.

5. A detector according to any of claims 1 to 4, wherein each Schottky barrier detector is

profiled with a smoothly undulating surface forming a series of alternating parallel grooves and ridges.

6. A detector according to any of claims 1 to 5, including means for measuring the electrical output of each of the Schottky barrier detectors.

7. A detector capable of demultiplexing *n* light signals respectively having differing wavelengths L1, L2 .... Ln substantially as hereinbefore described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon) Ltd, Dd 8991685, 1987.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.